REMARKS

The Office Action mailed on November 30, 2005 has been carefully considered and the Examiner's remarks are appreciated. Claims 1-46 were originally in the application. In response to a restriction requirement, Applicants previously elected Group I, claims 1-19 and 45-46 for prosecution, and claims 20-44 were withdrawn. In addition, claims 2 and 16 were previously canceled. Therefore claims 1, 3-15, 17-19, 45, and 46 are presented here for examination. Applicants respectfully request reconsideration of the rejection of claims 1, 3-15, 17-19, 45, and 46 in view of the amendments and the following remarks. No new matter has been added, with the amendments supported by the Specification, claims, and the drawings.

Discussion of the Rejections Under 35 USC §112

The Examiner rejected claims 1, 3-15, 17, 45 and 46 under 35 USC §112, first paragraph because of the limitation, "elastically compressed," as failing to comply with the written description requirement. Applicants respectfully submit that supporting disclosure for an elastically compressed intertwined free-standing CNT mesh is found in paragraph **[0028]** beginning on page 8, as follows:

> **[0028]** *As shown in Figure 1C, carbon nanotubes are then grown in the channel to produce an intertwined free-standing carbon nanotube mesh 14. The mesh is produced by passing products of hydrocarbon pyrolysis over the catalyst surface at elevated temperatures, e.g. above 800 degrees Celsius. Structural mesh parameters of height, density, and pore size are regulated mostly by the density and size parameters of the nanotubes. Both of these parameters are controllable by changing gas flows, flow ratios, and catalyst thickness. The grown carbon nanotube mesh 14 has pores of variable and tunable size on the order of 10-200 nanometers. The resulting mesh is stable in a variety of organic solvents and in air due to the nanotubes being chemically inert, and resists ultrasonication very well. Furthermore, carbon nanotube elements possess unique*

mechanical strength and elasticity which makes the mesh highly robust (emphasis added).

Taking this description of the elastic property of the CNT mesh together with the sealable capping description of Figure 1D (including all drawings), Applicants respectfully submit that an "elastic compression" is fully supported in the Specification, and therefore request reconsideration.

The Examiner also rejected claim 12 under 35 USC §112, second paragraph for lack of antecedent basis. The preamble (originally provided in application) was inadvertently omitted in Applicants' previous amendment. Applicants have made the appropriate correction by reinsertion.

Discussion of the Rejections Under 35 USC §103

The Examiner rejected claims 1, 3-15, 17-19, 45, and 46 under 35 USC §103(a) as being unpatentable over Dai et al (US 2004/0149209) in view of Noca (U.S. Pat. No.6,685,810). In support of his rejections the Examiner stated that Dai teaches the intertwined free-standing carbon nanotube mesh of the present invention but does not teach the structural specifics of the microfluidic channel, such as the channel and cover. For this the Examiner stated that Noca teaches the microfluidic channel with cover for use in separation processes. Applicants respectfully submit, however, that the Examiner has failed to make a prima facie case of obviousness since the cited references do not teach or suggest all claim limitations as required by MPEP §2143.03 as follows in part:

"To establish prima facie obviousness of a claimed invention, all the claim limitations must be taught or suggested by the prior art"

Regarding independent claims 1 and 45, the Examiner stated that the carbon nanotubes in the channel with cover taught by the references can have, *"some degree of inherent compression because they are random grown, and densely packed, and the carbon nanotubes can be inherently elastic, like that of applicant."* However, Applicants respectfully submit that the Examiner has erred in his reading of the above cited references and the parallels drawn with the present invention. While Applicants agree with the Examiner that such random grown carbon nanotubes are *"densely packed"* and *"inherently elastic"* due to their non-linear randomly extending structure, <u>it does not necessarily follow that they are also inherently compressed or inherently "elastically compressed."</u> Claim 1 specifically includes the limitation that the carbon nanotube mesh is "elastically compressed" and this is due to the packing of the mesh by the cover layer. The key is not simply that the mesh is densely packed, rather it is the fact that the mesh is packed and elastically compressed <u>by</u> sealably capping the channel with the cover layer. This intimate contact between the cover layer and the mesh helps to exert better flow control through the channel. To clarify this point, Applicants have amended claims 1 and 45 with the following:

> *"...a cover layer sealably capping said microfluidic channel to thereby pack <u>and elastically compress</u> the carbon nanotube mesh in the microfluidic channel"* (emphasis added).

The packing and elastic compression of the mesh is achieved in the present invention by growing the mesh to extend beyond the channel, as shown in the figures, and then compressing the mesh into to the channel. This is possible in part due to the mesh configuration with its irregular extensions providing the structural elasticity to be compressible without compromising the integrity of the nanotubes themselves.

In contrast, neither Noca or Dai teaches compressing the fabricated nanotube array to achieve good contact with the cover. In particular, Applicants submit that the vertically aligned configuration of the Noca nanotubes is inherently incompatible with the elastic compression and packing of the present invention, since such packing could jeopardize the integrity of the array if <u>axially compressed</u> by a cover.

Regarding claim 45 in particular, the Examiner stated that Dai also teaches the process as claimed in claim 45. Applicants respectfully disagree since the limitations in claim 45 require a microchannel and an elastically compressed mesh that is packed by a capping layer in the microchannel through which molecules are flowed. In the passages cited by the Examiner (paragraphs 2 and 44), Dai merely mentions that carbon nanotubes may be used in molecular filtration membranes. They do not, however, enable or otherwise teach or suggest the particular steps of the present invention by which molecules may be separated, concentrated and/or filtered.

Applicants respectfully submit, therefore, that the limitations in each of independent claims 1 and 45 are not all taught or suggested by either references, and therefore the 103-based rejections are inappropriate. Additionally, the rejections to claims 3-15, 17-19, and 46 are also inappropriate as being dependent on an allowable claim.

Regarding claim 3 in particular, Applicants have amended the limitations as follows to further clarify the packing function of the cover layer:

> *"wherein ~~at least a segment of said channel is filled with~~ said carbon nanotube mesh completely fills at least a segment of said channel so that the cover layer packs the mesh across the entire width of said channel segment."*

This is the embodiment shown in Figure 1D of the drawings. Again, there is no teaching in either the Dai or Noca references to completely fill the channel segment. On the contrary, the use of vertically aligned template grown nanotubes would perhaps suggest the opposite.

Regarding claim 4 in particular, Applicants have amended the limitations as follows to further clarify the packing function of the cover layer:

> *"wherein ~~at least a segment of said channel is surface coated with~~ said carbon nanotube mesh is surface coated over at least a segment of said channel with the nanotubes randomly extending from floor and sidewall surfaces of said channel segment without filling the segment ~~so as~~ to define a gap therethrough and so that the cover layer packs the mesh only along the sidewalls of said channel segment.*

This is the embodiment shown in Figure 2 of the drawings. Neither the Dai or Noca references teach or suggest surface coating the mesh over the entire surface of the channel segment without completely filling the segment. In particular, there is no teaching or suggestion for growing randomly extending nanotubes from all sides of the channel segment, including the floor and sidewall surfaces; both Dai and Noca teach growing carbon nanotubes on a horizontal plane, either by free-growth, or templated growth. Therefore, despite the Examiner's reliance on column 6, lines 45-54 of Noca describing the use of *"any shape, size or spacing of nanofeatures 20"* this language alone would not likely enable one of ordinary skill in the art to practice the particulars of Applicants' invention.

Regarding claims 5-8 in particular, the Examiner stated that Figure 6 in Noca and column 6, lines 45-54 describe the use of more than one mesh in a channel. A closer reading of this cited passage and Figure 6 of Noca indicates that this is not the case. While multiple channels with carbon nanotube arrays are shown in Noca, each channel has no more than a single mesh. The multiple meshes per channel of these embodiments of the present invention would enable multi-stage operation of separation, concentration, and/or filtration with breaks therebetween for possible intermediate sample preparation or processing. Furthermore, and as previously discussed, the complete filling or partial filling by surface coating of an intertwined free-standing carbon nanotube mesh is also not taught or suggested for claims 6 and 7.

And regarding claims 18 and 19 in particular, the Examiner stated that the nubbins are redundant and unnecessary since Dai in view of Noca teach the carbon nanotube mesh (54) as integral with or embedded in the channels (68). Despite the integration and/or embedding of the mesh in the channel, Applicants respectfully submit that the stress experienced by the mesh would be dependent on flow conditions, which may for example use pressure driven flow. In the unfortunate chance that the mesh broke off from its grown location in the channel, the nubbins would serve to prevent the mesh from being swept downstream. Thus the function of the nubbins is necessarily desired as a backup measure, to enable continued operation even after a failure in the structural attachment. Unlike the Noca reference which is primarily concerned with electrophoretic sieves, the present invention is intended, for example, for use in pressure driven flow, where breakage is a realistic concern.

Summary

Applicant therefore respectfully submits that claims 1, 3-15, 17-19, 45, and 46 are in condition for allowance, and requests allowance of claims 1, 3-15, 17-19, 45, and 46. In the event that the Examiner finds any remaining impediment to the prompt allowance of these claims that could be clarified with a telephone conference, he is respectfully requested to initiate the same with the undersigned at (925) 422-7274.

Respectfully submitted,

Dated: February 28, 2006 By:

James S. Tak
Attorney for Applicant
Registration No. 46,367

Lawrence Livermore National Lab
7000 East Avenue, L-703
Livermore, CA 94550
TEL: (925) 422-7274
FAX: (925) 423-2231